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COLLABORATIVE DEVELOPMENT IN THE VIRTUAL WORLD: DISCOURSE, DIGITAL ARTEFACTS AND THE CONSTRUCTION OF INTERSUBJECTIVE MEANING

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Abstract

The misconception of virtual worlds as 'games' has prevented these immersive environments from being treated as legitimate areas of inquiry by the Information Systems community. In this paper we argue that these environments challenge our conceptualisation of technology mediation due to the immersive and co-created nature of the digital environment, and particularly, challenges our understanding of information technology mediated collaborative development activities. Acknowledging the interrelated roles played by both human and non-human actors within virtual worlds, we investigate the construction of intersubjective meaning within three small synchronous collaborative development groups. Our findings highlight the complex roles of mediators within such collaborative activities in immersive environments, and the ways in which such mediation manifests through integrated socio-technical systems that are culturally developed.

Keywords: Virtual Worlds, Mediation, Collaborative Development, intersubjective meaning, Discourse, Digital Artefacts

1 Introduction

Open cultural virtual worlds (VWs) like Second Life (SL) have emerged as contexts for a variety of activities including research and development (Kohler et al., 2009), simulation and learning (Wankel and Kingsley, 2009) and business operations (Cagnina and Poian, 2009). We argue that VWs challenge our traditional understanding of both software and software development, for two reasons. First, the immersive nature of VWs changes the nature of user interaction, specifically the mediating function of software objects vis-à-vis user intention. Second, VWs like SL are co-created environments, constructed from within by the individual and collaborative efforts of its resident users, who create virtual goods (digital artefacts) which provide both utility and the potential for expressing wealth, power, status, individuality and belonging (Martin, 2008). In our work, we conceptualize VWs as collaborative development environments (cf. Booch and Brown, 2002) in which teams and groups of users may negotiate, brainstorm and work together in carrying out tasks to create executable products and supporting artefacts. Furthermore, we adopt Schultze and Rennecker's (2009) 'reframing of online games,' which conceptualizes the dualities of game-work and virtual-reality as mutually constitutive experiences. Building on their argument that these dualities have obscured such environments as legitimate areas of inquiry within Information Systems (IS), we posit that the dynamics of collaborative development in VWs represents a critical research area for the IS community.

In our work, we adopt an ontological position consistent with Actor-Network Theory (Latour, 2005), acknowledging the interrelated roles played by both human and non-human actors within a realm of activity, in order to better understand group cognition (Stahl 2006; 2009) within collaborative groups in VWs. Specifically, we gathered data from three collaborative development groups taking part in a community sponsored design event within SL, and analysed both the human discourse (behaviour of human actors) and the object discourse (meaning and behaviour of digital artefacts), which together mediate the construction of inter-subjective meaning (cf. Suthers 2006; Stahl, 2009; Rogoff, 1997) within such groups. In line with previous studies (e.g. Kohler et al., 2009; Girvan and Savage, 2010; Kohler et al., 2009; Chase, 2008) we focus on small groups as such groups afford an intermediate level of description and provide a locus for knowledge building, positioned at the 'middle ground' between individual cognition and that of wider community knowledge building (Stahl, 2009). In section 2 of the paper, we discuss our core theoretical concepts of mediation and group cognition in greater detail. In section 3 we describe our data gathering and analysis methods. This is followed by a presentation of our findings (section 4) which describe how human and object discourse mediate the construction of shared understandings of identity, problems and solutions. Finally, in section 5 we discuss the implications of our work.

2 Mediation and the Virtual World

In this section we discuss the concept of mediation in the context of the VW. Acknowledging the interaction between mediators during collaborative activities, we make explicit the importance of both human and non-human mediators in constructing shared meaning. In conceptualising mediation, we begin by employing Latour's (2005) distinction between intermediaries and mediators, in which intermediaries transport meaning unchanged whereas mediators are seen as continuous transformations within social associations that make societies and communities. Myriad studies focusing on interpreting user online collaboration have turned to theories and methods developed within social science, with distributed cognition, actor-network theory and activity theory being prime examples of such approaches (Stahl, 2006). Vygotsky's (1986) approach to collaborative learning focuses on individual psychology, with internalization of the social by an individual being the key form of mediation. Building on the work of Vygotsky, Leont'ev and Luria, cultural historic activity theory (c.f. Engeström et al, 1999) encompasses the assumptions that knowledge is mediated

through artefacts and the basic unit of analysis is what is defined as an activity. These artefacts encompass tools/instruments such as external (e.g. a hammer or a semiotic device such as a sign or symbol) as well as internal (e.g. ideas, plans). Tools and signs mediate self reflection, the behaviours of others, talk about self, as well as mediate the behaviour of self within object(ive)-oriented activities. Internal mental processes of people are materialized into mediating artefacts (instrumental and semiotic) and external actions via exteriorization (Kaptelinin, 1996), making ideas accessible to others through the creation of shared artefacts by people - subsequently supporting mutual understanding within a multi-user creative design process (Fjeld et. Al., 2002). Correspondingly, Internalization may be understood as the process from external to internal, moving from inter-subjective mental actions to that of intra-subjective actions.

Within a VW, the exteriorization of internal mental activities via the construction of virtual goods can be 'opened up' immensely as users may conceptualize their shared externalized artefacts (e.g. instruments, tools, signs & symbols) beyond the limits of the known structural properties of existing (actual world) objects - referred to as structured imagination (cf. Ward and Sonneborn, 2009). These artefacts (virtual goods) then become a persistent part of the environment in which users interact. It is these 'building blocks' within VWs that also provide individual users, groups, teams and communities with the ability to create virtual meeting spaces, auditoriums, and lecture halls, and various other places facilitating user interaction and learning within persistent spaces/places.

Next, discursive mediation relates to transactions between participants, with respect to the goal-actions. According to Wells (2007) it is seen as an operation of a dual nature, employing linguistic resources, co-constructing an appropriate genre of action that the discoursing mediates. First, discourse impacts (e.g. facilitates and constraints) material action (ancillary). Secondly, it co-constructs 'possible worlds' created and interpreted through the discourse itself (constitutive), such as identifying and explaining artefacts. Discourse, as a means of mediation, is acknowledged as a process emergent and co-constructed by participants over the course of their interaction (Wells, 2007) taking visual, narrative and symbolic forms, capable of elaborating knowledge artefacts (Stahl, 2009).

VW users are typically, but not exclusively, digitally and graphically anthropomorphized via the symbolic embodiment of customizable user-avatars (Barnes and Mattsson, 2008). It is through an avatar (which is itself a digital artefact) and its extensive modes of communication, that users are provided with a 're-embodiment' of presence (personal identity), placement (with regards to other users and objects), perspective (self-reflection/shared understanding) and place (geographic and social situations) within the system (Schultze et al., 2008). Avatar to avatar communication is established via text or voiced based chat (similar to that of traditional online communicative practices), as well as avatar gesturing (Kohler et al., 2009). Research approaches such as actor-network theory (Latour 2005) assume such ontological positions with regard to material-semiotic relations. Here collaboration in the VW is seen to involve participants as well as their semiotic and material artefacts. Jensen (2009) draws on the concept of intermediaries and mediators from actor-network theory in conceptualizing avatars as personal mediators and actants that transform actors during sense making processes as well as create personal stories and histories of their avatars. It is the interactivity between user-avatars as well as avatar-object interaction that enables rich collaboration within these immersive environments

Within online collaborative activities coordination emerges between users and artefacts, which collapse and resolve the distinction between technical and social forms into a meaningful whole for participants (Kelty, 2008). Suthers (2006) notes that for a technology to be fundamentally social, it should mediate and encourage acts of intersubjective meaning-making understood as the joint composition of interpretations, constituted in social interactions. Intersubjective meaning-making, as Suthers (2006) notes, must begin by first identifying 'uptake acts' where a subject takes up another's contribution and builds upon it, followed by understanding what subjects have accomplished through sequences of such uptakes acts. Given the uniquely interactive nature of VWs such as SL, human interaction in the form of narrative discourse between users/avatars provides only one way of 'knowing' what is occurring on an intersubjective level during collaborative work activities. Digital artefacts mediating the activity are thus understood to be intertwined with discourse in the

development of such group cognition (Stahl, 2009). Akkerman et al., (2007) review of empirical studies highlight two distinctive conceptual dimensions of group cognition; these being a cognitive perspective and a socio-cultural perspective; the latter of which we focus our study of collaborative development activities on. The cognitive perspective tends to focus on individuality and actions independent of the social structures or interactions on which this study is focused. Employing a socio-cultural perspective however, enables us to perceive group cognition as a coordinated process of participant contributions in joint activity, constituted by the group as an entity in itself. Finally, Akkerman et al., (2007) acknowledge that socio-cultural group cognition is capable of learning about the 'intrinsic personality' that complex systems such as groups/teams may endow. It is this agency within VW collaborative groups developing digital artefacts that this study aims to uncover through an examination of human discourse and digital artefact mediation within the VW. We acknowledge that this mediation is culturally and historically developed within a persistent and immersive environment.

3 Research Context and Method

The objective of this study is to explore the construction of intersubjective meaning within collaborative development groups in an immersive digital environment. This objective is operationalised by the following two research questions:

Research Question 1: How does human discourse mediate the construction of intersubjective meaning?

Research Question 2: How do digital artefacts mediate the construction of intersubjective meaning?

Here we took in consideration uptake acts constructed via the discourse produced by others as well as their virtual goods constructed during the collaborative development activity. Accordingly, the first research question focuses on dialogue co-produced by human collaborators, while the second research question compliments this line of enquiry by seeking to identify the affordances of digital artefacts within such collaborations. Given the exploratory nature of the study, suitable research strategies include a case study, a multisite case study or a field study (Marshall and Rossman, 1989) Case studies are appropriate when the object is to study contemporary events, and where it is not necessary to control behavioural events or variables (Yin, 1994), as here. The single case study method is considered to be a potentially rich and valuable source of data, while suited to exploring relationships between variables in their given context (Yin, 1994). Denzin and Lincoln's (2005) extensive review of qualitative research articulates the importance of data triangulation: "Humans are complex, and their lives are ever changing. The more methods we use to study them, the better our chances will be to gain some understanding of how they construct their lives and the stories they tell us about them" (pp.72).

The above research questions are combined in our analysis to illustrate the nature of intersubjective meaning-making during collaborative development activities. Based on the concepts previously discussed, the analysis of data begins by taking into account the culturally-situated and developed nature of activity, understanding intersubjective meaning-making at the establishment and maintenance of group and identity (section 4.1). Here identities are seen as social and cultural products that are developed. Next, analysis continues (section 4.2) by focusing on the mediation during negotiation of the problem space and the collaborative construction of design solutions. The case explored in this paper relates to a social 'group building' event organized by the SL learning community, New Citizens Inc. (NCI) in 2010. The event was communicated to all members via the groups own internal 'notice' system. Twenty six users in total were present throughout the event, whereby eleven users, forming four development teams, competed in a group building contest moderated by a community event officer. Each group competed to design a structure based on the theme "I want Candy" for a 45-minute period. Users present then voted on the four designs, resulting in a winning group. Table 1 presents a brief outline of the various user categories present during the event.

Users	Description
Moderator	Established and maintained the activity.
Group Purple	Two Users with a strong pre-existing social relationship. During the contest the group decided to build a diorama ¹ displaying a trick or treat scene.
Group Blue	Three users. No Pre-existing social relationship. The group decided to build a diorama displaying a candy store.
Group Green	Three users. No pre-existing social relationship. The group decided to build a diorama displaying a trick of treat scene.
Group Red	Three users. The group decided to build a diorama of a candy store.
Non-Participants	Numerous observers entering and leaving throughout the activity

Table1: User Categories

Various methods were employed in the collection of data, including; real-time observation of development activity carried out by users as well as participation in auxiliary activities such as voting on designs and contributing to the community funded prize donation of Linden dollars to winning users. In addition, public text-based chat logs constructed by participating members and numerous observers were recorded (including time stamp). Enabling the narrative discourse between users, private and public instant messaging (IM) tools inherent to the SL viewer provided a linguistic medium in which intersubjective meaning was established and developed by participants. Following the event, three out of the four participating development groups voluntarily provided the private text chat logs relating to group conversations prior, during and immediately after the event. The remaining group communicated using private audio chat functionality (provided by the SL viewer) and so no recording was made available of the groups discourse. Having identified uptake acts through conversational analysis (Stahl, 2009) of the text chat logs produced by each of the three groups (groups Green, Blue and Purple), the data presented a composite genre consisting of ancillary and constitutive discourse. Of particular interest in the context of our first research question, the constitutive discourse mediates inter-subjective meaning by functioning to co-construct a ‘possible world’ (created and interpreted by the discourse). Next, the consumption of visual discourse between participants is inherently more difficult to capture given users individual perception and sense of personal immersion within the environment. However, certain signs and symbols, such as the creation, modification and movement of virtual goods as well as avatar gestures and movements, communicate vast operations and actions of users. Given our symmetrical treatment of humans and non-humans, observations also heavily focused on interpreting the roles of users own artefacts. We note four distinguishable categories of digital artefacts observed to mediate the construction of intersubjective meaning within the VW: the SL viewer, the virtual environment in which the activities occurred, the avatar(s), in-world objects. Using the functionalities provided by the SL viewer, it was possible to unobtrusively observe users and their objects via a ‘fly-by’ camera view. In addition, the ability to ‘inspect’ objects (within limits) enabled the examination of object meta-data properties; presenting information on object ownership and sharing/accessibility settings as well as highlighting development practices, such as ‘prim² linking’ (connecting two or more objects into a single cohesive object).

4 Analysis and Findings

In this section we discuss the analysis and findings of our study, describing how virtual goods, herein referred to as (in-world) objects, as well as avatars and human discourse mediate the construction of intersubjective meaning. In structuring our analysis and findings we present central intersubjective meaning making processes observed during the synchronous collaborative development activities;

¹ Each of the design models, consisting of numerous virtual goods/objects were seen to depict a scene (such as Halloween, trick or treating, etc).

² Customisable, 3D, geometrical objects

these begin with the establishment of group and identity (section 4.1) within a socio-technical and cultural developed environment, followed by analysis of the negotiation of the problem space and the collaboratively-constructed design solution (section 4.2). The establishment and maintenance of group, and identity is a worthwhile process as far as participants are concerned. In carrying out the activity itself the creation of roles and responsibilities by participants and objects, as well as the sharing of objects were all constructed via acts of intersubjective meaning making, facilitating and constraining both human and non-humans (e.g. avatars and objects) throughout collaboration.

4.1 Establishing Group and Identity

When we consider the role of digital artefacts and human discourse in constructing intersubjective meaning in relation to group and identity, there is much to consider. As an open development environment, the need to construct group identity is critical in separating participants from all other non-participant actors that are subsequently present within the shared design space. Rather than implementing any technical exchange structures such as utilizing the explicit Group³ or Friend sharing functionalities provided by the SL viewer, the groups were 'formed' (e.g. Group Green, Purple, etc) by the narrative discourse and the symbolic scripts inherent within objects and avatars surrounding participants.

Firstly, the NCI community was seen to place conditions on activity in which certain values and traditions influences collaborative acts. For instance the event rules introduced by the moderator dictated the manner in which users participated. Participants interpreted the situation as a contest in which one must follow the rules of the host/moderator (the human mediator). Using cultural artefacts such as a clock (as seen in Figure 1, left and right images) the moderator was able to transform the situation and take agentive action (the end of the contest signalled by the clock turning red and displaying the word "stop"), situating the collective activity within a time constraint (45 minutes) of which the moderator controlled. This is understood as *explicit* mediation in which the intended introduction of signs mediates ongoing flow of activity. Figure 1 (left and right images) displays the coloured "squares" locating participants (typical of many NCI events/classes) and providing team zones in which groups were located.

Secondly, the inscription of objects can also be seen to celebrate a shared tradition, in this case Halloween, inspiring everything from the contest and atmospheric theme (I want Candy/Halloween) and avatar design (with many users 'dressing up' in Halloween themed avatars). This suggests that examination of collaborative construction activities needs not only to acknowledge 'how' users engage in activity, and 'what' they create but also 'when' they choose to do so.

Next, users created 'personal objects' – those understood to have a special signification for an individual. Figure 1 (right image) highlights a design made by one of the members of the purple group and placed on the square as a "custom collar tag" explicitly claiming the square. The creation and use of such "collar tags" are also examples of the explicit mediation. Its design, as informed after the event, was modelled after an "alchemical transmutation circle" and held "very special meaning" to him. Here the sign is acknowledged at its multi-viewed perspective, in which the collar tag held personal meaning for its owner, while communicating intension and authority (over the purple zone) of his group to the collective.

³ A SL group is a formal (public or private) organisation within the VW, consisting of two or more users, enabling the sharing of objects in-world between members.



Figure 1: The mediating roles of in-world Objects

Intertwined with strategic involvement and self-authoring, identity is seen here to develop as one narrates oneself as a group member in the given environment. Here we take note that participants may create personal stories and histories of their avatar that transform them into the mediators of being in the VW. Such transformation were evident in our analysis, with some users identifying themselves and others as businessmen and leaders before collaboration even took place, with meta-data relating to avatar profiles providing further deceptive personal statements, building on these stories and histories. Furthermore, despite the ability for users to customise their avatars, none of the group engaged in creating a group ‘outfit’ for their avatars in establishing their shared identity for the event. However, both participants in group Purple oriented their avatars in close proximity to each other at all times, arriving at the event ‘wearing’ matching anthropomorphic ‘furry’ avatars, visually establishing their pre-existing social relationship to all. Here, *implicit* mediation (e.g. signs in the form of natural language that have developed over-time) can be seen in the way that users ‘instinctively’ communicated with others within the environment.

Furthermore, participants were seen to acknowledge a sense of group identity, utilizing collective pronouns (we, us) and referring to themselves by group name. Discourse relating to group Green and Blue’s establishment highlights a ‘schoolyard style uptake process’ in creating a shared group identity; externalizing the optimism (“*Pick me!, join us*”) and despair (*I’ll join but I may be a liability*”; “*I’m prepared to make an ass out of myself in the interest of science*”) inherent within the groups. In comparison, both participants within group Purple, having an existing social relationship (very strong⁴), indicated their intentions of working as a group by signalling desires for self selected group formations⁵ as well as lack of desire in working apart. Here a formative intervention occurred whereby one member argued for making his own self-selected group, consisting of himself and one other user (his friend), rather than be part of a randomly formed group as was first instructed by the moderator. Such interventions can transform user’s behaviour as well as the nature of the activity (in this instance changing the rules of the group formation, in which the moderator agreed to the request). While the construction of roles and responsibilities of participants within each of the groups was later implicitly and explicitly constructed via narrative discourse throughout activity, observations of avatars however acknowledged the uptake act of avatars positioned on the coloured development zones several minutes before the event commenced. This was seen to inscribe the role of participant to many of the avatars that actually took park, contributing to the establishment of group identities. These coloured zones even provided the name by which each participant group would go on to identify itself with in discourse (referring to themselves as part of either group green, purple, red, or blue). Members from groups Green and Blue were acknowledged to begin the transformation from individual user to participant by the positioning there avatars on the coloured zones. The intersubjective meanings with

⁴ Have collaborated and socialised together in-world previously

regards to this transformation are seen in the avatars spatial and temporal locations. Here a group assembler or initial group member was implied pre-contest by the fact that an avatar was first positioning on one of the available development zones. Discourse available clarifies this interpretation as subsequent users were seen to request permission from these primary users in joining a group, before any discussion of roles or participation began.

4.2 Negotiation of Problem Space and Design Solution

Narrative discourse was seen to develop a shared understanding of the problem space and design solution engaged by each of the groups, building common ground in which the development activities were motivated towards. From ancillary discourse, comes the construction of inter-subjective meaning between participants, which is both confirmed and ‘materialised’ via the construction and modification of design objects – prim based items – within each of the groups. Rooted in acknowledgment of the theme “I want Candy”, each group engaged in constitutive discourse uptake acts, seeing the creation of shared design objectives. Interestingly, Group Purple agreed on a shared ‘vision’ without conflict, simply building a shared understanding through building agreement back and forth - from designing a “child” to “beggars day type” design to making it special by designing “different costumes”. The remaining two groups however, engaged in negotiation in developing a design solution. For instance, Group Green negotiated over the exact nature of the “house” component – a “door” was suggested by one participant, while another countered with a “house” design. Subsequently, a “facade” was agreed as the proposed design solution.

Green1: I was thinking.. a door.. kid trick or treating? ... but.. i can do a house.. ish

Green2: That [door] also [comes]with a house

Green1: [I'm]only gonna do a house front.

Green2: Nods i will make the surroundings

As for group Blue, their shared perception of a design solution remains somewhat unclear throughout, development; while design components were agreed (e.g. furniture, building, candy) their relationship to each other (e.g. scale, proximity) were constantly negotiated to the end of the activity, resulting in ‘on the fly’ modifications to designs. Rooted in the development of myriad design artefacts from all participants were elements of virtualization of infrastructures ‘ferried’ from analogue artefacts e.g. gardens, doors, paths, windows, facades, fences, etc. These easily recognizable, scripted cues were observed to act as signs and symbols mediating the association, function and expectation of artefacts between participants. The subsequent use of these analogies ‘glued’ individuals in their approach to developing artefacts, focusing the externalization of designs to explicitly mimic ‘actual world’ capabilities and design, providing a contextualised system of meaning. The use of the word “nod” in the above extract (indicating acceptance of Green1’s proposal) as well as numerous emoticons shared between groups and non-participants, highlights the complexity of user to user gesturing, which was seen to incorporate IM, avatars, as well as in-world artefacts e.g. some developers voluntarily sat their avatars in chairs, while non-participants also sat their avatars on the side bench provided. There is an apparent contradiction here in the fact that user-avatars feel a need for seating in-world despite the fact that avatars do not get tired from moving/flying within the environment (on the contrary, avatars run a ‘sleep’ gesture after lengthy periods of inactivity). Equally, seating an avatar on an object, such as a chair, can be understood as a societal and personal concept motivated from everyday ‘actual world’ practices of humans, which have become routinely and often implicitly mediated into the everyday VW practices of user-avatars and their objects (humans and non-humans).

In relation to constructing objects, the problem space in which these solutions were agreed upon, incorporates the set development zones in which each group constructed a shared design consisting of 100 prims or less. This constraint scripted within the shared understanding of a solution by all groups, facilitated users in managing the coordination of tasks, with users seen to track and manage their sharing of artefacts.

Green1: Ok 33 prims each and [we'll] see who will need the last one

Green 3: [I] am at 21 prims [and] will need more than 33

Green 1: Ok you can take 10 [prims] from me

Green 3: thank you

Green 3: [It]will be 37 [prims] looks like

Green 1: Ok [i'm] stealing 4 from you

Green 3: okies

Next, entwined in the discourse acts relating to the establishment and maintenance of shared design solutions were the establishment of role making processes seeing members constantly engaged in defining the status of labour division (via nominating, volunteering and instructing) in relation to roles and responsibilities. Rather than undertake individual speciality roles of 'builder', 'scripter', or 'texturer' as may be the case in an analogue equivalence (e.g. builder, electrician, or painter) all participants share development tool functionalities enabling them to take up roles in an adaptive and virtuous manner. The enrolment of participants into design modular tasks, externalizes an envisionment of events according to leading participants. Only group Green were seen to explicitly engage in uptake acts delegating leadership to a single participant; while any comparative role of leadership within the other two groups was merely implicitly contested through uptake acts relating to requests/proposals. In the case of Group Green where leadership was established, the leader requested that one member state his skills.

Green2: How are your build skills G1? ...What are you best at?

Green1: Krys... he wants to know how my building skills are..

Green1: G2.. I've run a business here in SL building for over 4 years

Green2: Nods need to know what you build best

Green2: Okies well i do not know and what do you make?

Green2: I've won quite a few blitz builds over the years... in fact.. the very first blitz build I ever did, and was the first thing I ever built in SL.. I won second place

Green1: I can build, texture, and I have an inventory of holding.. you need it.. I [probably] got it

Again, narrative discourse remained key in establishing the combined and potentially shared resources of the group. In comparison, no such discussions took place within Group Blue, leading to the assignment of work expectations beyond one user's (initial) ability – subsequently forcing the user to engage in a learning task of selecting appropriate textures for the design artefacts. As a shared vision of 'what goes where' and 'who can do what' were absent, confusion and a need to redesign on the fly emerged. Finally, no such discussions relating to resources took place in Group Purple. This is perceived to be a result of the strong existing relationship and history in which both members shared.

Furthermore, discourse was also observed to develop and clarify meaning relating to user designs. In group Blue and Purple, users sought clarification as to the nature of a design artefact ("is that the floor? /is that the ghost head") in which confirmation was immediately established by another group member ("yes") bringing about a shared understanding. Despite the formation of groups to construct objects, the question remains – were the objects created by users simply an 'accumulation of stuff' rather than collaboratively made objects? For example, Figure 2 (left image) presents an image of the Green groups design solution under construction. The house prop seen here was constructed and designed by one user; another member designed/constructed the mannequin prop being created here, while the third group member designed/constructed the sounding setting. Inspection of the meta-data of the grass textured floor object in the image highlights reveals that it was constructed by an individual user. Such practice was seen to be common amongst all four groups. For instance in the red group, one user created the building facade while two others made mannequin props. Again, in the blue group, one user again built the building prop, while the other two members each built individual props to be placed inside. Interestingly, in both groups Purple and Blue instances of close collaboration in which users exchanged and made accessible their digital artefacts to other participants were observed.

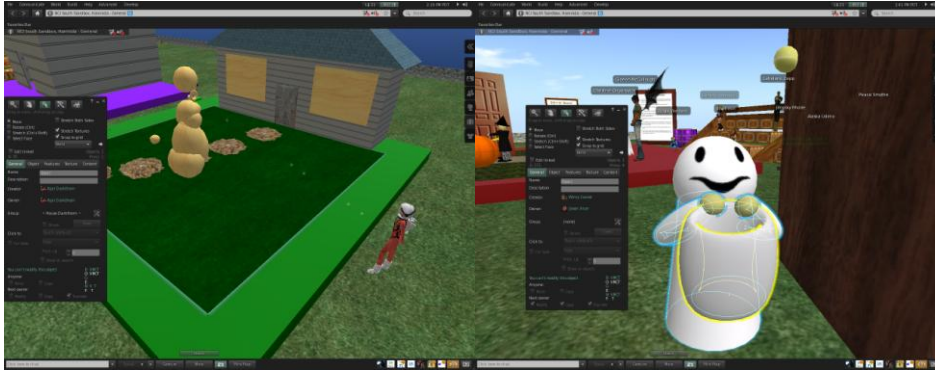


Figure 2: Cooperation and Collaboration in the Construction of In-world Objects

Figure 2 (right image) displays a (multi-prim) object designed as a ghost prop that was collaboratively constructed by both members of group Purple. Here users enrolled their objects with their collaborative intentions by customising their objects permission settings to explicitly enable open modification or movement by others. For other participants in the group to respond to such operations, narrative discourse commenced in which the sharing participant informed others of the sharing act - the shared roles of the objects and the expectation the sharing participant had of other participants subsequently was expressed by the state of the artefact (e.g. the object is now shared).

Finally, as none of the groups utilized the 'SL group' collaborative tools in constructing their shared identity, none of the artefacts created by participants were under explicit technical control by 'a group' of users or leader at any time during the collaboration. Such practices are understood to be beyond the traditional norms of NCI practice during community events. Instead, the intersubjective meaning developed via discourse acts between humans and their digital artefacts is seen to inscribe their solutions as being 'group owned'. However, no single participant owned a finished group design, nor were all the 'pieces' (objects) integrated into single cohesive (multi-prim) objects; to do so would of required additional explicit negotiations of ownership and shared object permission settings within the groups.

5 Discussion and Conclusions

Open cultural VWs have enjoyed years of growing attention from multiple disciplines with regards to their collaborative capabilities and specifically their potential use by organizations and educational institutions as collaborative work and collaborative learning environments. In this paper, our analysis reveals that the construction of intersubjective meaning within collaborative development groups in VWs is accomplished through the composition of interpretations and subsequent uptake acts, both in the form of Human and non-human (avatars and objects) discourse. We argue that 'societal knowledge' and 'personal concepts' that are mediated within these collaborations are motivated through intertwined 'actual world' practices, traditional forms of online practices and, here, practices specific to the VW. Bringing this enquiry into collaborative development into the VW further and developing more structured methodological frameworks for analysing activities and interactions within SL, meaning and action within SL may also be digitally recorded via inscribing in-world objects with 'sensory' scripts capturing episodes of activity relating to users and their objects qualitatively and quantifiably over-time. However, we note that by conditioning users to employ new, and potentially unfamiliar, operations (such as placing complex sensor scripts into each object they create) researchers knowingly transform and condition the collaborative activity being studied.

Next, in constructing collaborative design solutions, both human and non-humans engage in uptake acts relating to problem and solution definition, role assignment and knowledge sharing. Our findings suggest that coordination between users and objects within VW collaborative development activities favours adaptability over strict planning (e.g. explicit goals, negotiation and consensus). Here

adaptability is understood as the critical and responsive public direction of a collaborative activity, resolving the tensions between individual virtuosity (such as technical skills, fluency and design style) and the need for collaborative control (cf. Kelty, 2008). In fact, the collaborative control of the artefacts constructed by the groups in the case explored in this paper simply did not exist in any technical sense. Rather, the interactions between participants (and non-participants) sharing the immersive design space are coordinated and governed by the management and meaning assigned to digital artefacts created by users; communicating roles, identities, boundaries and culture. In addition, VWs differ from other collaboration environments (e.g. Lotus Notes) where the tool ultimately serves as a simple conduit. In contrast the culturally historic and persistent nature of the VW transforms and mediates activity in the specialized sense used in this work.

We note that a considerable constraint in co-creating and co-owning shared objects within the VW is the inability for objects to contain artefacts owned by two or more individual participants. Therefore, it seems that the intellectual property system digitally embedded within user created digital artefacts, dictating the accessibility of digital artefacts in the VW, has both facilitated in the construction of virtual trade and commerce, while ultimately conditioned artefacts within collaborative scenarios to be individually modifiable by default. In comparison to the leaner collaborative environments utilized by Stahl (2006, 2009), VW collaboration is indeed a much more complex system for constructing inter-subjective meaning in developing collaborative solutions. While Stahl's environments provide adequate mediators in solving structured problems such as math based problems, users of VWs can inscribe 'meaning' in objects at a level of symbolic richness on par with that of narrative discourse. The culturally embedded and historically developed nature of the immersive environments and the context that comes with it, allows us to explore more unstructured problems such as, for example, those associated with psychological issues, sustainability, population growth, or other socio-economic issues.

Finally, we note that the IS field has traditionally taken a rather human-centric approach to studying technology and technology mediation. While VW studies have used both qualitative and quantitative approaches, these studies predominantly treat human and technology as separate. Our study demonstrates the fundamental interplay between human and non-human actors in enacting collaboration in the VW. Thus we argue that the human/technology dualism dominating much of IS research is insufficient for studying immersive VWs. As a result, emergent epistemological positions such as sociomaterialism (Orlikowski and Scott, 2008) may ultimately prove more appropriate for these environments, representing a fundamental challenge for IS researchers.

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